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Comparison and Analysis of New Echocardiographic Parameters as Predictors of Immediate Outcomes of REDO PTMC

Ravella Keerthika Chowdary[1*],
Vamsi Krishna kamana[2],
Rama kumari Nuthalapathi[1]

[1]Department of Cardiology, Nizam's Institute of Medical Sciences, Hyderabad, India
[2]Department of Cardiology, Cardiology Gandhi hospital, Secunderabad, India

Abstract

Mitral stenosis still continuing to be a cause of morbidity and mortality in this part of the country. Restenosis rates after PTMC are 10-20%, and after CMV 20-40% in the coming 2 decades [1]. In REDO PTMC the valve is fibrotic and commmisural morphology which is split in the first procedure becomes fibrotic and calcified. The routine scores which analyze the valve does not take into consideration the commercial morphology so we aimed to study new Echocardiographic parameters and comparison with the existing scores in predicting immediate outcomes of REDO PTMC.

Methods and Results: 42 symptomatic patients with mitral restenosis who have undergone REDO PTMC were enrolled and they were divided into 2 cohorts on the outcome as optimal (n=27) and suboptimal (n=15) groups Mean WILKINS SUTARIA and New REDO score were 7.89, 2.33, 8.96 in optimal group, 8.53, 1.60, 10.20 in suboptimal group with significant p value of 0.007 for new REDO score predicting its superior sensitivity over other 2 scores.

AIMS & OBJECTIVES

AIM: To study new quantitative parameters of the mitral valve apparatus by using Echocardiography to predict the immediate REDO PTMC outcomes.

OBJECTIVES:

1. To evaluate the role of 2D Echo parameters of mitral valve apparatus in predicting the immediate REDO PTMC outcomes.
2. To study the correlation between mitral valve leaflet displacements from the annulus, PML/AML ratio, MAC, chordal length, commissural morphology in immediate REDO PTMC outcomes.
3. To determine combination of new parameters REDO SCORE in predicting immediate REDO PTMC out comes [2].
4. To compare new REDO echo scoring system with Wilkins score [3].
5. To compare new REDO echo scoring system with Sutharia scoring system [4].

Materials and Methods

The study was conducted in the Department of Cardiology, NIZAMS Institute of Medical Sciences, Hyderabad from September 2014 to November 2016. Forty-two consecutive patients who underwent REDO PTMC were included in the study after taking informed consent.

Inclusion criteria

All patients with symptomatic and moderate and severe Mitral restenosis undergoing REDO PTMC were included in this study [5].

Exclusion criteria [6]

1. Persistent left atrial or left atrial appendage thrombus
2. More than moderate mitral regurgitation
3. Massive or bicommissural calcification
4. Severe concomitant aortic valve disease
5. Severe organic tricuspid stenosis
6. Severe concomitant coronary artery disease requiring bypass surgery (or) history of cardiac surgery.

Ethical clearance

Institutional ethical committee clearance was obtained for conducting the study.

All the patients included in the study were evaluated as follows. Chief complaints like

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***Corresponding author:**

Ravella Keerthika Chowdary
Department of Cardiology
Nizam's Institute of Medical Sciences
Hyderabad
India
Tel: 91-9491544225
E-mail: ravellamk@gmail.com

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breathlessness and pedal edema were noted and history of present illness was recorded. Relevant past history,personal history and treatment history were taken. General examination was done and anthropometric recordings like height, weight, BMI, body surface area were recorded. Vitals of the patient were noted. Cardiovascular examination was followed by other system examination.

Blood samples of patient were collected and hemoglobin, blood urea, serum creatinine random blood sugar analysis and blood grouping were done.ECG of a patient was taken . Trans thoracic 2D Echocardiographic examination including MV area (cm^2), peak gradient (mmHg), mean gradient (mmmHg), right ventricular systolic from TR jet,Wilkins score, Maximum leaflet displacement (mm),Doming distance , PML/AML ratio <0.5 as per American Society of Echocardiography were recorded.

Echocardiographic and Hemodynamic data [7-9]

Transthoracic, M-mode, 2-dimensional, and Doppler echocardiography were performed on the day before and within 24 hours after REDO PTMC using a Philips IE-33 machine. All patients underwent a Transesophageal echocardiography within 24-48 hours prior to PTMC in order to exclude the presence of left atrial thrombus and to assess valve morphology. MS was quantified by planimetry of two-dimensional images, Doppler measurement of trans-valvular gradients, and estimation of valve area by the pressure half-time method.

MR severity was evaluated by integrating data from the color flow image,[23]analysis of the vena contracta,[24]and study of the pulmonary venous systolic reflux [10]. The continuous-wave Doppler tricuspid regurgitant velocity was used to determine systolic pulmonary artery pressure (SPAP) using the simplified Bernoulli equation assigning a value of 10mmHg to account for right atrial pressure. Left atrial (LA) volume was assessed by the biplane area-length method from apical 2-and 4-chamber views. All results were based on the average of three measurements for patients in sinus rhythm and five measurements for patients with atrial fibrillation. Hemodynamic measurements include systemic blood pressure, heart rate, left atrial pressure (LAP), left ventricular end-diastolic pressure (LVEDP), end diastolic gradient (EDG), mean diastolic pressure gradient (MDG) before and immediately after PTMC.

Mitral valve assessment for REDO PTMC

The morphology of the mitral valve was assessed by the Wilkins scoring system based on mitral valve mobility, thickening, calcification, and sub valvular apparatus . Each parameter has a scale of 1-4. The highest score represent the more abnormal structure, total Echo score will be obtained from adding all parameter scores. According this score 4 was total normal valve , score 16 represent immobile valve with leaflet calcification

Commissural morphology assessment [11]

Commissural morphology assessment was done by a qualitative visual assessment where MVA mitral valve area was obtained by tracing the inner margin of leaflets from the parasternal short axis view (Figure 1) and Outer surface of the leaflets was traced. Symmetry of commissural thickening was assessed and accordingly classified as open , partially fused ,completely fused, unilaterally or bilaterally. Weather they are calcified or not depending on the specks of calcium.

Assessment of leaflet displacement [12]

Leaflet displacement was assessed in apical 4 chamber view as the distance from the mitral annulus to maximal leaflet displacement during diastole. Doming distance >12 is given a score of 1 and <12 is given score of 2.

Transesophageal echocardiography (TEE) [8,9]

All patients underwent TEE immediately before PTMC with a5 MHz multiplanetransoesophageal probe and Philips I 33 ultrasound scanner. The mitral valve leaflets and subvalvar apparatus were examined at mid-oesophageal and transgastric levels. The mitral commissures were scanned systematically at the mid-oesophageal level. The anterolateral commissure was visualized in the transverse plane by advancing and retracting the probe, thereby scanning the length of the commissure from the leaflet tip to the annulus. The posteromedial commissure was scanned in the longitudinal plane by rotating the probe clockwise and anticlockwise (Figure 2) [13].

Mitral valve anatomy viewed from the left atrium with orientation of the transverse and longitudinal Transesophageal planes.

Commissural calcification was identified by high intensity echoes casting an acoustic shadow (Figure 3) [2,12].

Calcified anterolateral commissure seen in the transverse midoesophagealplane. LA, left atrium; LV, left ventricle; RA, right atrium.

Sutaria score

Sutaria et al. [13], investigated the value of Transesophageal (TEE) echocardiography in the assessment of commissural morphology and prediction of outcome after PTMC. Anterolateral and posteromedial commissures were scored individually according to whether non-

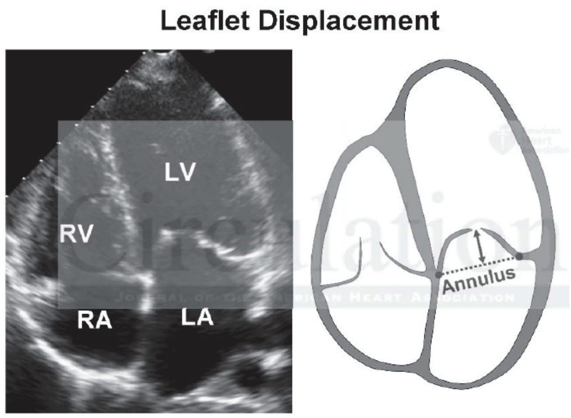

Figure 1: Leaflet displacement

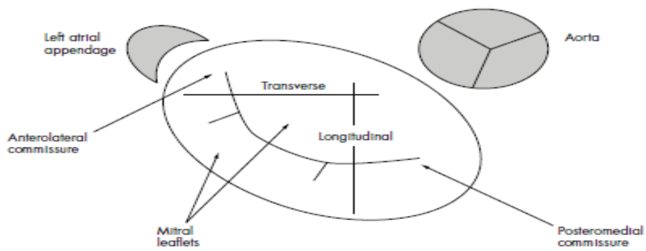

Figure 2: Mitral valve anatomy viewed from the left atrium with orientation of the transverse and longitudinal transoesophageal planes.

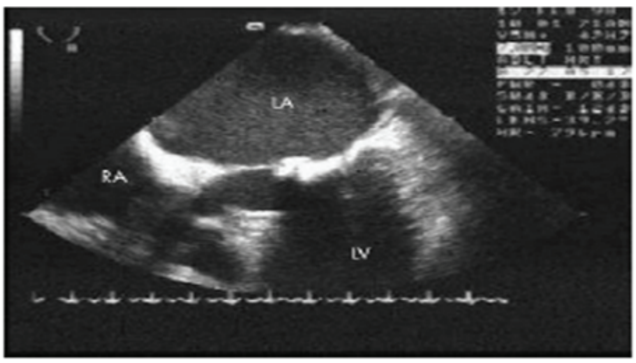

Figure 3: Calcifiedanterolateral commissure seen in the transverse midoesophagealplane. LA, left atrium; LV, left ventricle; RA, right atrium.

calcified fusion was absent (0), partial (1), or extensive (2).Calcified commissures usually resist splitting and scored 0. Scores for each commissure were combined giving an overall commissure score for each valve of 0–4, higher scores reflecting increased likelihood of commissural splitting. Commissure score was the strongest independent predictor of outcome.

Rajashekar et al. [14] studied to validate the importance of assessing the morphology of mitral valve commissures by TOE and thereby predicting the outcomes after PTMC. The Commissural morphology and Wilkins score were assessed by TEE. Both the commissures (anterolateral and posteromedial) were scored individually according to whether non-calcified fusion was absent (0), partial (1), or extensive (2) and calcification (score- 0) and combined giving an overall commissural score of 0-4. Outcome of PTMC was correlated with commissural score and Wilkins score. And intercommisural16 diameter is used by some investigators in predicting success [15].

A higher commissural score predicts a good outcome after PTMC hence it can be concluded that along with Wilkins score, commissural morphology and score should be assessed with TOE in patients undergoing PTMC.

New REDO Score [2,12]

A simplified REDO score which takes Independent echocardiographic parameters were assigned points

Mitral valve area **<1 = 2** points

PML/AML ratio **<1/2 = 2** points

Doming distance < 12mm = 3 points

MAC mild = 1 point, moderate 2 points severe 3 points

Chordal length < 10mm 2 points

Commissural status: NO FUSION= 0

UNIFUSION=2

BIFUSION= 3

The minimum score was 5 and maximum 13. Score < 8 favourable outcomes and >8 unfavourable.

Cardiac catheterization/Percutaneous Transvenous Commissurotomy: [16,17]

Hemodynamic parameters of left atrial pressure and left Ventricular end diastolic pressures were measured before and after PTMC. Mitral valve commissurotomy was performed with an ACCURA balloon catheter by the trans-septal (Brockenbrough) technique.

Procedural success and endpoint definitions [18]

Procedural success was defined as an increase of 50% of mitral valve area or a final area of 1.5 cm^2, with no more than one grade increment in MR severity assessed by echocardiography 24 hours after the procedure. The reference measurement for MVA was done in two-dimensional echocardiographyplanimetry.

Results

In the present study, we evaluated 42 patients who underwent REDO PTMC for Mitral restenosis. We divided into two groups based on result optimal group and Suboptimal group. Optimal outcomes were obtained in 27 patients and sub-optimal outcomes were obtained in 15 patients. Demographic, clinical and biochemical profile is shown in Table 1. Baseline characteristics of optimal group and Sub optimal group are shown in Table 3.

Demographic and Clinical characteristics of study population

AGE: Study population included patients with age 18 to 64 years. Mean age of the study population was 37.51±10.29 years. The majority of patients were in the age group of 30-45years. Mean age of patients in the suboptimal outcomes group was 37.44 ± 9.27 years and in the optimal outcomes group was 37.51 ± 10.14 years. There was no significant statistical difference in age between two groups (p =0.83) (Figure 3).

Sex distribution: Out of 42 patients, 28 (62.8%) were females and 14 (37.2%) were males. There was no significant gender difference between two groups (P= 0.83) (Figure 4).

Body surface area: Average body surface area (BSA) of the total study population was 1.41±0.18m^2. In sub optimal outcomes group, the average body surface area was 1.40±0.19m^2 and in optimal outcomes group it was 1.41±0.16m^2. There is no statistically significant difference in body surface area between the two groups (p= 0.65).

COMMISURE SCORE	COMMISURE MORPHOLOGY
0	Neither commissure fused or calcification of both commissures or absent fusion of one commissure and calcification of the other
1	Partial fusion of one commissure and absent fusion or calcification of the other
2	Extensive fusion of one commissure and absent fusion or calcification of the other or partial fusion of both commissures
3	Extensive fusion of one commissure, partial fusion of the other, and no commissural calcification
4	Extensive fusion of both commissures and no commissural Calcification.

Table 1: Commissure score (sutaria) based on Transesophageal Echocardiographic assessment [11]

CHARACTERISTIC	MEAN±SD / n(%)
AGE(years)	37.51 ± 10.29
MALE:FEMALE	18:24
HEIGHT,(cm)	157.82 ± 8.12
WEIGHT ,(kg)	47.09 ± 9.29
BMI, (kg/m^2)	18.81 ± 2.96
BSA, (m^2)	1.45 ± 0.15
PR (bpm)	82.5 ± 7.15
SBP(mm of hg)	109.1 ± 8.50
DBP(mm of hg)	78.45 ± 5.28
Hb (gm /dl)	12.81 ± 1.64
RBS(mg/dl)	99.74 ± 38.52
B. UREA(mg/dl)	26.14 ± 7.44
S.CREATININE(mg /dl)	0.76 ± 0.21

Table 2: Baseline Characteristics of the Patients

BMI=Body Metabolic Index, **BSA**= Body Surface Area, **PR**= Pulse Rate, **SBP**= Systolic Blood Pressure, **DBP**=Diastolic Blood Pressure, **HB**=Hemoglobin, **RBS**=Random Blood Sugar, **B.UREA**=Blood Urea, **s.creatinine**= Serum Creatinine

VARIABLE	OPTIMAL OUTCOME (n=27)	SUB-OPTIMAL OUTCOME (n=15)	p-val
Age, yrs	37.51 ± 10.14	37.44±9.27	0.83
Female	17	05	0.72
Male	10	03	0.68
Atrial Fibrillation	07	04	0.17
Past h/o 2 procedures	05	02	0.67
Time gap from last procedure	14.66	10.37	0.477
Past h/o CMC	09	02	0.03

Table 3: Comparison of Baseline characteristics in Optimal & Sub-optimal outcome groups

PTMC percutaneous transvenous mitral commissurotomy CMC closed mitral valvotomy.

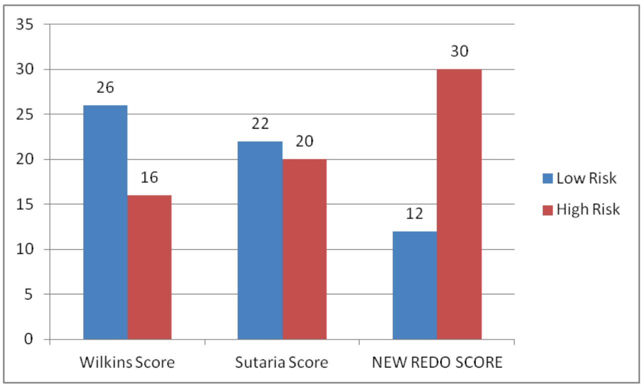

Figure 4: Risk Distribution of Patients in Various Scoring System

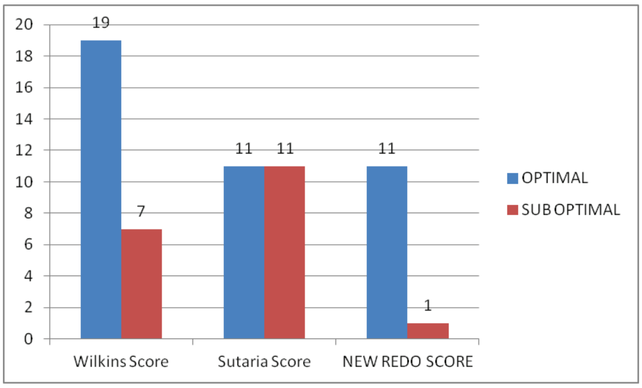

Figure 5: PTMC Outcomes in High Risk Group

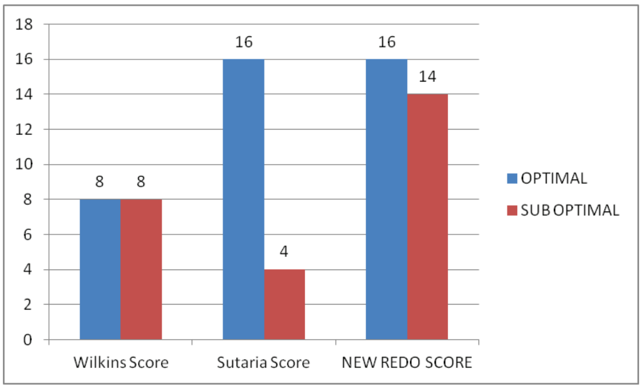

Figure 6: PTMC Outcomes in LOW Risk Group

Symptoms

Presenting Complaint: The most common presenting complaint was dyspnea, which was present in 99% (n=33) of the patients. Eleven (31.4%) patients presented with palpitations (due to AF with fast ventricular rate). One (2.8%) patients presented with hemoptysis and chest pain was presentin6 (17.1%) patients.

Past History: Past history of rheumatic fever was present in 14 (40.0%) patients. Nine 9 (25.71%) patients had undergone a history of Closed Mitral Valvotomy as the first procedure. Seven (20%) patients underwent 2 previous procedures, there is no statistical difference between the groups. The history of a Cerebrovascular accident was present in 1 patient.

Echo Cardiac Parameters: Pre-procedural transthoracic parameters are shown in Table 4. Post-procedural Transthoracic 2D echo cardiac parameters are shown in Table 5.

Mean mitral valve area was 1.00±0.15 (cm^2) and1.08±0.19 (cm^2) in optimal and suboptimal outcome groups respectively (p =0.23). Mean mitral valve gradient, peak mitral valve gradient, systolic pulmonary artery pressure and LA size were not statistically significant between two groups. LA thrombus was absent in both the groups.

In this study average Post PTMC mitral valve area in the optimal outcome group was 1.67 ± 0.09cm^2 and in sub optimal outcome group was 1.04 ± 0.42 cm^2 (p =0.001). Mean mitral valve gradients were 4.62 ± 1.69 mmHg and 6.52 ± 4.08 mmHg (p=0.025) and peak mitral valve gradient was 7.14 ± 3.39 and 9.54 ± 2.52 (p=0.02) which are statistically significant in either commissure split or bilateral fused commissures group respectively.

There was no statistically significant difference in, systolic pulmonary artery pressures between the two groups.

In haemodynamic study, POST PTMCLA mean pressure in optimal group was 8.43 ± 4.66 mmHg, and suboptimal group was 11.71 ± 3.72 mmHg which were statistically significant difference (p = 0.02). There was no statistically significant difference in pre PTMC, mean LA pressures in both groups and also there was no statistically significant difference in pre and post PTMC LVEDP in both groups Table 6.

There was a no statistically significant difference in pre MV area, between optimal and suboptimal groups. There was a statistically significant difference in mean New REDO scores between optimal and suboptimal outcomes groups (p=0.007) but only borderline statistical significance in Wilkins score and Sutaria score (p=0.06 and p=0.06 respectively) Table 7.

There was only statistically significant difference of commissural fusion and MAC between optimal and sub-optimal outcomes groups (p<0.05 and p=0.02 respectively). There was no statistically significant difference in mitral valve area doming distance, chordal length and PML/AML ratio in both groups (p=0.25, p=0.81 p=0.40, p=0.96) Table 8

Immediate outcomes in different sub groups stratified according to Wilkins and New's scoring system is represented in Table 2,4 while that of Sutaria and New's scoring system is shown in Table 9,10.

PARAMETER	OPTIMAL RESULTS GROUP	SUB OPTIMAL RESULTS GROUP	p-value
MEAN MITRAL VALVE GRADIENT(mmHg)	13.86±5.56	12.00±2.83	0.38
PEAK MITRAL VALVE GRADIENT(mmHg)	22.75±6.44	20.57±4.65	0.40
SYSTOLIC PULMONARY ARTERY PRESSURE(mmHg)	47.93±12.95	45.86±15.13	0.71
MV AREA (cm^2)	1.00±0.15	1.08±0.19	0.13
LA SIZE	3.99±0.54	4.06±0.28	0.36

Table 4: Pre Procedural TTE Echo cardiac Parameters
MV AREA=Mitral Valve Area .LA: Left Atrium

	OPTIMAL RESULTS GROUP	SUB OPTIMAL RESULTS GROUP	p-value
Mean MV Gradient(mmHg)	4.62±1.69	6.53±4.08	0.001
Peak MV Gradient(mmHg)	7.14±3.39	9.54±2.52	0.02
S PAP(mmHg)	37.29±8.48	39.29±9.44	0.26
MVA (cm^2)	1.67±0.42	1.04±0.09	0.0001

Table 5: Post Procedural Echocardiographic Parameters
LA V=Left Atrial Volume, SPAP=Systolic Pulmonary Artery Pressure, MVA=Mitral Valve Area.

VARIABLE	OPTIMAL RESULTS GROUP	SUB OPTIMAL RESULTS GROUP	p-Val
PRE LA MEAN PRESSURE (mmHg)	18.92±5.85	18.75±6.55	0.27
POST LA MEAN PRESSURE (mmHg)	8.43±4.66	11.71±3.72	0.02
PRE LVEDP (mmHg)	8.89±1.74	8.71±1.60	0.44
POST LVEDP (mmHg)	7.29±3.85	6.29±5.62	0.18

Table 6: Cardiac Catheterization Data
LA =Left Atrium, LVEDP= Left Ventricular End Diastolic Pressure

	Optimal group (N=27)	Sub optimalgroup (N=15)	p-valve
Wilkins score (total)	7.89±1.18	8.53±0.74	0.06
Sutaria Score	2.33±1.24	1.60±1.12	0.06
New Score REDO SCORE	8.96±1.45	10.20 ±1.14	0.007

Table 7: Comparison of means of different scoring systems in Optimal & Sub-optimal groups

PARAMETER	OPTIMAL RESULTS GROUP(N=27)	SUB OPTIMAL RESULTS GROUP(N=15)	p-value
MV area(cm^2)	1.52±0.50	1.33±0.48	0.25
DOMING DISTANCE (mitral valve displacement in mm)	1.33±0.55	1.67±0.61	0.81
COMMISSURAL FUSION	1.59±1.11	1.01±0.67	0.05
MAC	1.30±0.46	1.70±0.70	0.02
CHORDAL LENGTH	1.67±0.48	1.53±0.51	0.40
PML/AML ratio	1.74±0.44	1.73±0.45	0.96

Table 8: Comparison of Echocardiographic parameters in NEW REDO scoring system

Wilkins Score		NEW Score		
		Low	High	Total
Low 26	Number of Individuals	11	15	26
	Sub-optimal	01	06	07
	Optimal	10	09	19
	Proportion of Sub-optimal	09	40	26
High 16	Number of Individuals	01	15	16
	Sub-optimal	00	08	08
	Optimal	01	07	08
	Proportion of Sub-optimal	0	50	50
Total	Number of Individuals	12	30	42
	Sub-optimal	01	14	15
	Optimal	11	16	27
	Proportion of Sub-optimal	8.3	50	22.8

Table 9: Immediate Outcome identified by Wilkins &Nune's scoring systems

Sutaria Score		NEW Score		
		Low	High	Total
Low 22	Number of Individuals	03	19	22
	Sub-optimal	01	10	11
	Optimal	02	09	11
	Proportion of Sub-optimal	33.3	50	50
High 20	Number of Individuals	09	11	20
	Sub-optimal	0	04	04
	Optimal	09	07	16
	Proportion of Sub-optimal	0	30	25
Total	Number of Individuals	12	20	42
	Sub-optimal	01	14	15
	Optimal	11	16	27
	Proportion of Sub-optimal	8.3	70	30

Table 10: Immediate Outcome identified by Sutaria & Nune's scoring systems

Post procedural complications

Six patients developed moderate to severe MR, out of which one patient required emergency mitral valve replacement. One patient developed CVA and peripheral embolisation.

Discussion

In this study, we observed that:

1) New REDO scoring system has highest positive predictive value than other scores [2,12].
2) New REDO scoring has greater sensitivity and comparable specificity than Wilkins scoring system.
3) Sutaria scoring system has greater sensitivity and lower specificity than new scoring system [4].
4) Commissural morphology and MAC have positive correlation with outcomes [11].

Parameters to predict Immediate PTMC Outcomes [18]

Data from large series indicate that, the predictors of outcomes following PTMC are multifactorial. Apart from morphological characteristics of the valve, following clinical and procedural variables predict the outcomes following PTMC.

1. Age
2. Gender
3. Functional Class
4. Effective Balloon Dilation Area
5. Final Valve Area
6. Mitral Valve Gradients
7. Fluoroscopic Mitral Calcification
8. Previous Mv Intervention
9. Pre-Ptmc Mean pulmonary artery Pressure
10. Presence of Atrial Fibrillation.

And the most important final factor in case selection is the experience of the clinical team.

In our study patients who had successful PTMC had lower values of Wilkin's and New REDO score, Higher Sutaria score, less mitral commissural calcification, mitral leaflet thickness and commissural fusion.

Previous MV intervention was not associated with sub optimal outcomes, Similar to the findings of Guptha et al. [19] who analyzed 614 consecutive patients undergoing PTMC including 84 patients (13.7%) with mitral restenosis following prior surgical valvotomy. They found that percutaneous balloon mitral valvotomy can be performed safely and effectively in patients with mitral restenosis following surgical valvotomy.

In our study, patients who had successful PTMC had lower Wilkin's and New REDO score, and lower commissural calcium score, consistent with the findings of Nobuyoshi, et al and Hung, et al who demonstrated that a more abnormal echocardiographic morphology predicted less symptomatic improvement and had a smaller post procedure valve area [2,12,20].

The Wilkins Echocardiographic score is used widely to guide patient selection for PTMC . This score is based on an assessment of leaflet thickness, mobility, calcification and the extent of subvalvular disease. Commissural morphology is not included, which is an important predictor of PTMC outcome [3]. Although this scoring method has been widely employed due to its simplicity and reasonable success in separating patients with successful versus unsuccessful outcomes based on an increase in valve area, the grading of individual components remains semi-quantitative, subject to observer variability and less reliable in classifying patients with scores within the mid-range. The best combination of parameters to predict the outcome remains to be defined.

Since the onset of PTMC a number of echo cardiac parameters and scores to assess the mitral valve anatomy and function, have been proposed to predict procedural outcomes and patient selection.

These parameters are broadly divided into two groups

1) Parameters that relate to an optimal increase in valve area and [21]
2) Parameters predicting MR.

Predictors of increase in mitral valve Area

The mechanism underlying the increase in valve area after PTMC is splitting off one or both fused mitral commissures similar to surgical commissurotomy. Therefore, increase the MVA after PTMC is minimal, if commissural fusion is absent or if the commissures resist splitting because of the presence of calcium.

Studies examining predictors of a successful increase in mitral valve area have yielded varying results. Wilkins et al. [1] scoring system which included an assessment of leaflet mobility, calcification, fibrosis and subvalvular apparatus. No single parameter individually predicted the outcomes, but all the parameters together (total score) significantly predicted outcomes. In developing the Echocardiographic score, the morphological components were weighed equally to form the total score despite their difference in location or nature (e.g., leaflet versus chordal position or valvular mobility versus valvular thickening). Therefore, these components might not have the same effect on the outcome of the procedure. Thus, differential weighting of individual components could result in a more predictive scoring system.

Sutaria et al.[6] developed commissural scoring system by TEE for assessment of mitral commissures immediately before PTMC in 76 patients. They found that the value of TEE in assessing mitral commissural fusion and calcification in patients undergoing PTMC is reproducible and a useful predictor of immediate outcome after PTMC. Consistent with this, our study also showed that, commissural calcium score has negative correlation with PTMC outcome (P =0.003).Sutaria score is able to predict outcomes better in the risk group compared to WILKIN and NEW score but in high risk group SUTARIA score is inferior.

New score reported that quantitative assessment of the maximal leaflet's displacement from the annulus was the predictor of a successful increase in valve area. Leaflet's displacement appears to incorporate the effects of leaflet thickness, calcification, and commissural fusion into a single variable, and can be accurately measured in a consistent reference imaging plane.

However, in our study maximal displacement of the leaflet from the annulus did not predict the outcomes (p= 0.89) as a single parameter. But overall NEW score is able to predict outcomes better in REDO PTMC than WILKINS and SUTARIA scores (p=0.007)

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